

APPLICATION OF THE BETHE-WEISS METHOD TO THE THEORY OF ANTIFERROMAGNETISM

BY

YIN-YUAN LI

B.S., National Southwest Associated University, China, 1943
M.S., University of Washington, 1948

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS
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APPLICATION OF THE BETHE-WEISS METHOD TO THE THEORY OF ANTIFERROMAGNETISM

The Bethe-Weiss statistical method developed in the theory of ferromagnetism¹ is applied to antiferromagnetism by introducing sublattices. In this method a cluster consisting of a single atom and its first shell of neighbors is taken into consideration in detail and the interactions between this cluster and the rest of the assembly are replaced by an internal field; the Hamiltonian of the cluster is properly diagonalized. Atomic lattices (spin $\frac{1}{2}$ per atom) with the negative Heisenberg exchange coupling J between the nearest neighbors are investigated. It has been found that the two-dimensional lattices cannot sustain antiferromagnetic order. The Curie temperatures of the simple cubic and b.c.c. structure are respectively $2.004 |J| / k$ and $3.18 |J| / k$. That the f.c.c. lattice cannot be ordered by the interactions among the nearest neighbors is deduced from the disorder of a quadratic layer and the ineffectiveness of the interactions between layers in a f.c.c. lattice in producing order. This helps to understand why the ordering pattern of spins of Mn ions in MnO should be such as observed by Shull². The curves of reciprocal susceptibility and of short-range order vs. temperature above the Curie point T_c are obtained. The experimental formula $\chi = \text{const.} / (T + \theta)$ is compared with our theory. We obtain for the simple cubic and b.c.c. lattice $\theta = 1.5T_c$ and $1.25T_c$ respectively if we extrapolate our theoretical curve from extremely high temperatures, and θ is slightly higher than these values if we extrapolate from the temperature range at which experimental readings are taken. This is more favorable in a comparison with the experimental data than the prediction $\theta = T_c$ of the molecular field theory³. Our calculation gives a discontinuity of specific heat of $1.0k$ at the transition temperature of a simple cubic lattice. One section of this paper is specially devoted to a discussion of the general validity of our theory and its failure in the range of low temperatures.

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VITA

Yin-Yuan Li was born on May 25, 1919 in Chengtu, Szechuan Province, China. He was graduated from the National Southwest Associated University (Kunming, China) in June 1943 with a degree of Bachelor of Science. He began his graduate work in the University of Washington in 1947 on an Exchange Student Fellowship and received a degree of Master of Science in 1948. In September 1949 he entered the University of Illinois and held a research assistantship.

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